E Appendix E - Hydrological Assessment

Flood estimation report

Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines (Version 5, 2015). It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

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Approval

	Name and qualifications	Date
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Abbreviations

AM..... Annual Maximum

AREA..... Catchment area (km^2)

BFI..... Base Flow Index

BFIHOST..... Base Flow Index derived using the HOST soil classification

CFMP..... Catchment Flood Management Plan

CPRE..... Council for the Protection of Rural England

FARL..... FEH index of flood attenuation due to reservoirs and lakes

FEH..... Flood Estimation Handbook

FSR..... Flood Studies Report

HOST..... Hydrology of Soil Types

NRFA..... National River Flow Archive

POT..... Peaks Over a Threshold

QMED..... Median Annual Flood (with return period 2 years)

ReFH..... Revitalised Flood Hydrograph method

SAAR..... Standard Average Annual Rainfall (mm)

SPR..... Standard percentage runoff

SPRHOST..... Standard percentage runoff derived using the HOST soil classification

Tp(0)..... Time to peak of the instantaneous unit hydrograph

URBAN..... Flood Studies Report index of fractional urban extent

URBEXT1990..... FEH index of fractional urban extent

URBEXT2000..... Revised index of urban extent, measured differently from URBEXT1990

WINFAP-FEH..... Windows Frequency Analysis Package – used for FEH statistical method

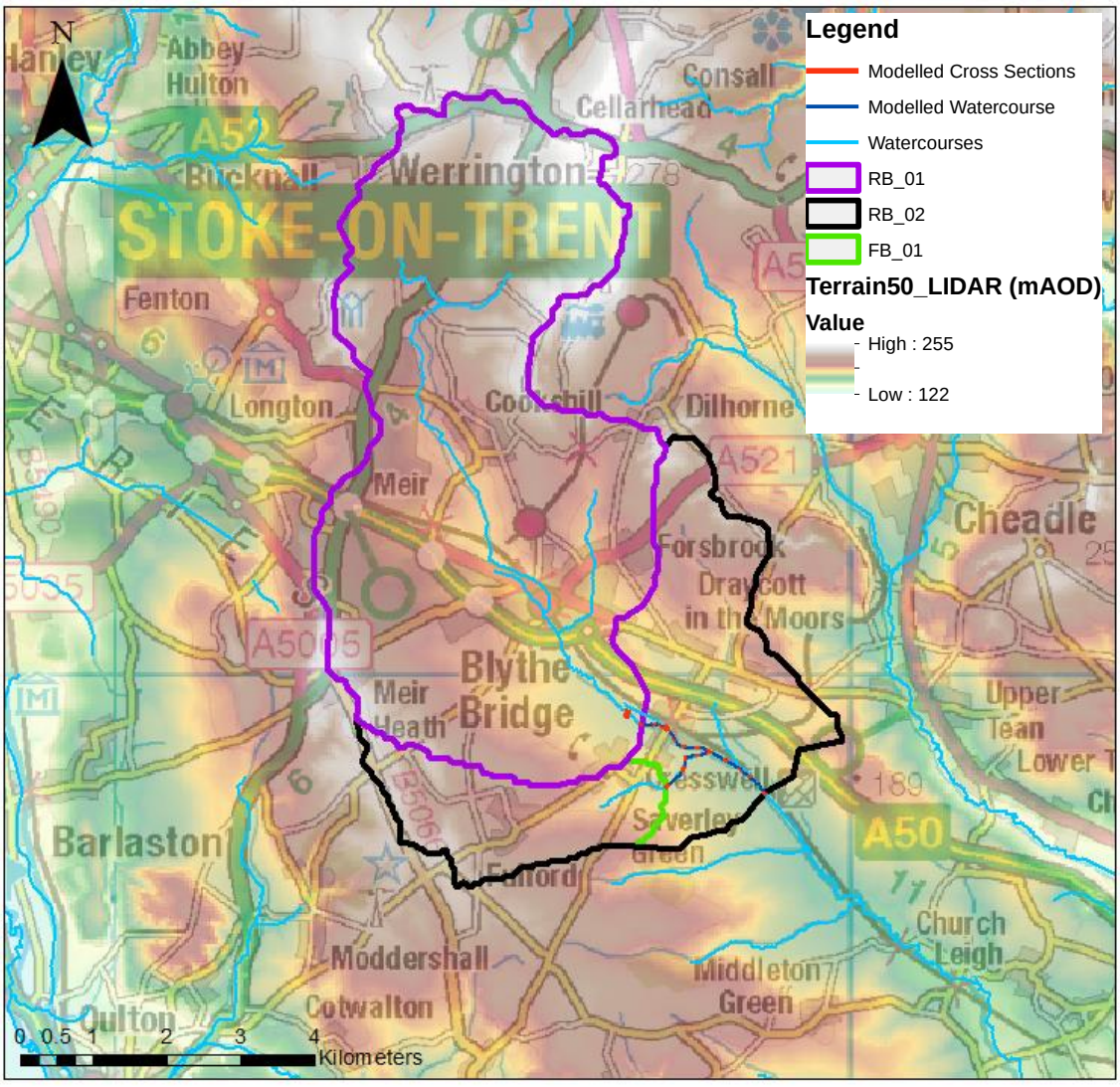
1 Method statement

1.1 Requirements for flood estimates

Item	Comments
Overview • Purpose of study • Peak flows or hydrographs? • Range of return periods and locations	The purpose of this assessment is to provide inflows into a hydraulic model of the River Blithe and Fulford Brook, to support a discharge of Planning Condition 15 at Blythe Park, Cresswell Road, Staffordshire. Planning permission has been granted for a mixed-use development on either side of the existing Blythe Park Industrial Estate. Planning Condition 15 states that "prior to the commencement of any development on the site, a detailed hydraulic model of the River Blithe and the ordinary watercourse crossing the site shall be submitted to and approved in writing by the Local Planning Authority in consultation with the Environment Agency". The modelled return period flood events will be the 20-year (5% AEP), 100-year (1% AEP), and the 1,000-year (0.1% AEP). *For climate change, the relevant factor (in line with February 2016 guidance) will be applied to the 100-year flow estimates in the hydraulic modelling phase.*

1.2 The catchment

Item	Comments
Map (Include river network, catchment boundary and gauging stations)	



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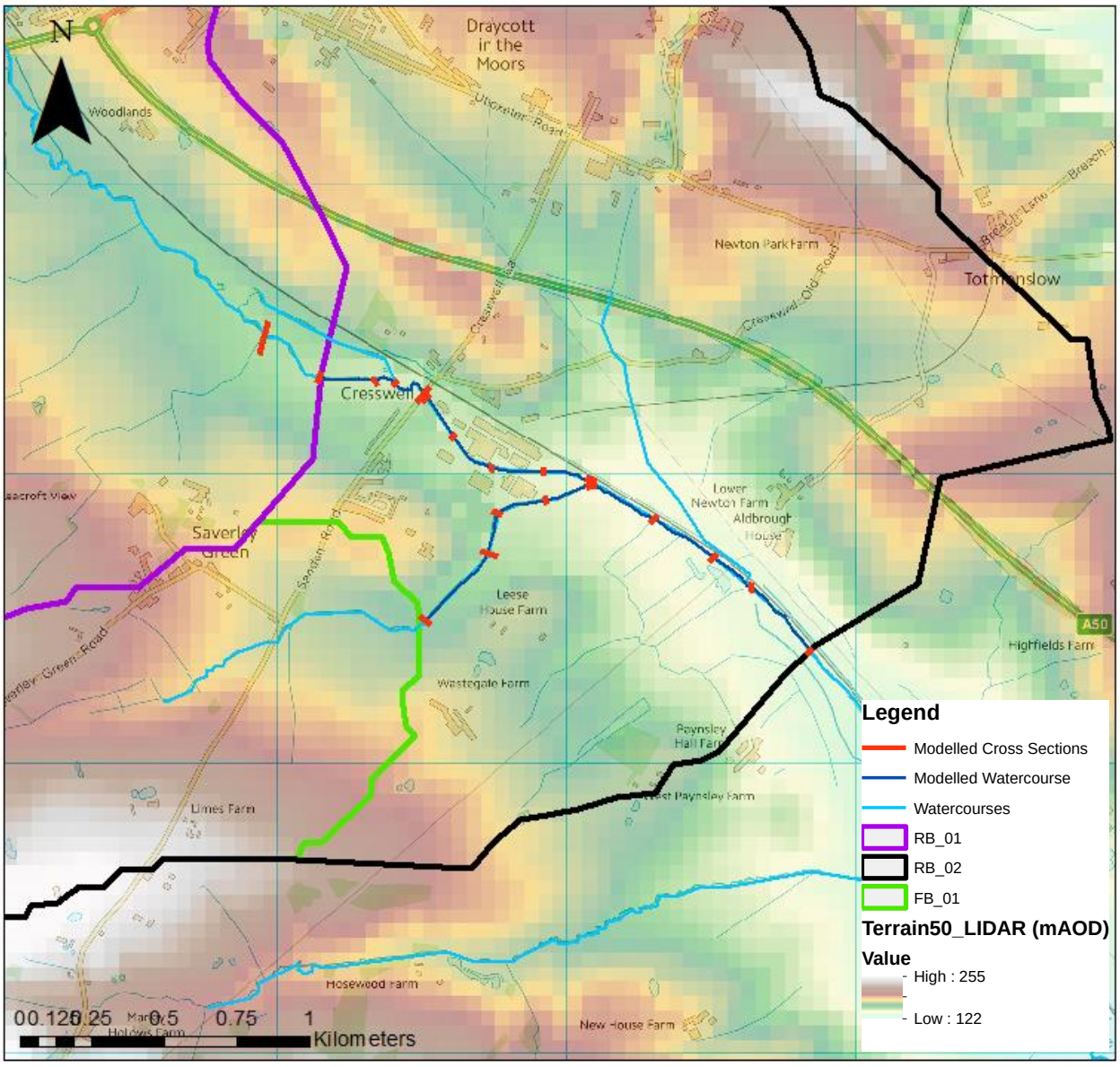

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Description Include topography, climate, geology, soils, land use and any unusual features that may affect the flood hydrology.	The proposed development is a mixed-use development with a residential focus to the west and an employment focus to the east, either side of the existing Blythe Park Industrial Estate. The site is bounded by the River Blithe to the north and the Fulford Brook to the south-east and Sandon Road to the west with green space to the south. As the proposed site straddles the Industrial Estate with a connecting road, the Fulford Brook forms the north-western boundary of the eastern proposed development site. The River Blithe flows in an easterly/ south-easterly direction along the site's northern boundary. The Fulford Brook joins as a right-bank tributary shortly downstream of the business park/ development site. Another drain enters the River Blithe as a left-bank tributary near Lower Newton Farm, shortly upstream of the modelled downstream boundary. The site generally slopes in a south-north direction from the higher ground to the south and west towards the watercourse to the north. The River Blithe dominates local topography around much of the site. The site is partially located within the Environment Agency's Flood Zone 2 and 3, though much of the site is in Flood Zone 1. The site lies within an area of naturally high groundwater along the River Blithe corridor, where soils are loamy. The upper catchment is mixed, with some slowly permeable, seasonally wet soils and some slightly acid loamy and clayey soils. The soils are impermeable, with a BFIHOST value of between 0.48-0.57.

1.3 Source of flood peak data

Source Record any changes made	NRFA peak flows dataset, Version 4.1, May 2016. This contains data up to water year 2011-12 for England, Wales and Northern Ireland and up to water year 2005-6 for Scotland.

1.4 Gauging stations (flow or level)

(at or very near to the sites of flood estimates)

Water-course	Station name	Gauging authority number	NRFA number	Catchment area (km²)	Type (rated / ultrasonic / level…)	Start of flow record and end if station closed
Catchment is ungauged in the modelled study reach. Gauge 28002 Blithe @ Hamstall Ridware is located 25km downstream of the study site, and 5km downstream of Blithfield Reservoir.						

1.5 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings (if planned to review ratings)	N	There are no gauges within the study catchment (upper Blithe catchment) and no rating review was required as part of this study. Gauge 28002 is much further downstream and south of a large reservoir which would account for attenuation effects not seen in the upper catchment.		
Historic flood data Include chronology and interpretation of flood history in Annex or separate report.	Y	A search for historical records of flooding was undertaken. Past Flood Risk Assessments at the site (Jacobs, August 2014), state that a significant flood event occurred in 1987, inundating the business park, parts of Sandon Road and gardens of residential properties. Following this event, a bridge within the site was removed following a blockage event to reduce flood risk impacts. No site-specific information was found in the Stafford Borough Council SFRA (2008).		
Flow data for events	N	N		
Rainfall data for events	N	N		
Potential evaporation data	N	N		
Results from previous studies	N	N		
Other data or information (e.g. groundwater, tides)	n/a	n/a		

1.6 Hydrological understanding of catchment

All catchments	
Outline the conceptual model, addressing questions such as: • Where are the main sites of interest? • What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	The main site of interest is a proposed mixed-use development site at Cresswell, between Sandon Road, the railway line and the watercourse. Flood risk is most likely to be runoff-driven from the surrounding steep topography. The site is also close to the confluence of the River Blithe and the Fulford Brook, where some interaction may take place in the event of a flood. Sandon Road bridge and the railway line may also cause blockages or impoundments in the event of a flood.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if BFIHOST>0.65, consider permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – seek local flow data; consider method that can account for differing sewer and topographic catchments • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully	There are no unusual features in the catchment. It is not permeable and has no reservoir influence. The catchment is moderately urbanised.

1.7 Initial choice of approach

Is FEH appropriate? (it may not be for extremely heavily urbanised or complex catchments). If not, describe other methods to be used.	Yes.
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	FEH Statistical and ReFH methods will be tested and compared. The flow estimates at the top of the modelled extents will be input into the model as inflows. The lumped downstream estimate is for guidance purposes in the model, and instead a lateral catchment will be inserted into the model between the top two inflows and the downstream extent. The model will use ReFH boundaries to obtain hydrographs.
Software to be used (with version numbers)	FEH CD-ROM v3.0[1] WINFAP-FEH v3.0.003[2] Flood Modeller Pro

[1] FEH CD-ROM v3.0 © NERC (CEH). © Crown copyright. © AA. 2009. All rights reserved.
[2] WINFAP-FEH v3 © Wallingford HydroSolutions Limited and NERC (CEH) 2009.

2 Locations where flood estimates required

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

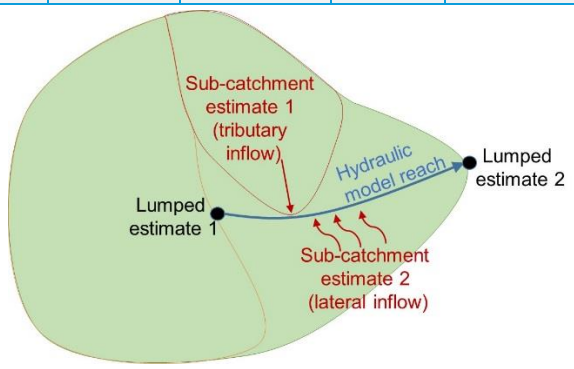
2.1 Summary of subject sites

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA on FEH CD-ROM (km^2)	Revised AREA if altered
RB_01	L	River Blithe	Upstream model extent	397100	339350	31.93	32.13
FB_01	L	Fulford Brook	Upstream model extent	397450	338450	4.71	-
RB_02	L	River Blithe	Downstream model extent	399300	337800	47.07	45.52
RB_Lat	S	-	Intervening area to be inserted in the model between RB_01, FB_01 and RB_02	-	-	8.68	-

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



2.2 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 1990*	URBEXT 2000*	FPEXT
RB_01	1.000	0.44	0.480	6.70	45.0	867	0.079	0.113	0.067
FB_01	1.000	0.44	0.575	2.34	53.6	841	0.013	0.026	0.0156
RB_02	1.000	0.44	0.520	8.10	44.9	862	0.059	0.085	0.0691

*Updated to 2017

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (add maps if needed)	Catchment boundaries from the FEH CD-ROM were checked against Ordnance Survey maps and Opendata LIDAR. Only minor changes were made to the catchment boundaries of RB_01 and RB_02 around the watercourse itself, to better account for small drain crossings. The rest of the catchments are very well defined.
Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.	Qualitative check on FARL using mapping. BFIHOST checked using BGS soil maps. DPLBAR changed as a result of catchment area changes.
Source of URBEXT	$URBEXT_{2000}$ (used for FEH Statistical method) $URBEXT_{1990}$ (used for ReFH1 method)
Method for updating of URBEXT	CPRE formula from FEH Volume 4 CPRE formula from 2006 CEH report on $URBEXT_{2000}$

3 FEH Statistical method

3.1 Search for donor sites for QMED (if applicable)

Comment on potential donor sites	
Mention: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors • Quality of flood peak data Include a map if necessary. Note that donor catchments should usually be rural.	An assessment of donor stations was carried out for this study using WINFAP-FEH to assess stations that are suitable for QMED within the HiFlows-UK dataset. The search area was restricted to 20km because the effect that the new data transfer method has on QMED adjustment becomes negligible when the distance between catchment centroids is greater than 10km. Gauges within catchments over several orders of magnitude larger were discounted from further consideration. Three gauges were considered further, all of which were suitable for deriving Qmed and were of an appropriate catchment size and proximity to the study catchment: • Gauge 28002 Blithe @ Hamstall Ridware is located within the study catchment, but at the downstream end of the catchment and 5km downstream of Blithfield Reservoir. • Gauge 28040 Trent @ Stoke-on-Trent is located close to the catchment, is suitable for Qmed and was considered further as a donor. • Gauge 28061 Churnet @ Basford Bridge is located close to the catchment, is suitable for Qmed and was considered further as a donor.

3.2 Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing	Method (AM or POT)	Adjust-ment for climatic variation ?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
28040	**Rejected:** The catchment is affected by impounded reservoirs, and the catchment is urban.	AM	n/a	11.30	16.29	0.589
28061	**Rejected:** The QMED adjustment at the gauge based on catchment descriptors and observed data is 0.872. Although the description of the gauge in HiFlows states bypassing occurs just after QMED, there is a lot of scatter in the spot gauges; the majority of which suggest lower flows for a given stage. The scope of the assessment does not include an assessment of the quality of gauge data, and given the uncertainty regarding the rating, it was decided to reject this donor, especially as it would have resulted in a downward adjustment in QMED at the subject site.	AM	n/a	29.39	33.70	0.842

NRFA no.	Reasons for choosing	Method (AM or POT)	Adjust-ment for climatic variation ?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
28002	**Rejected:** Although this gauge is located downstream within the study catchment, it is heavily influenced by the Blithfield Reservoir (which is located approximately 5km upstream of the gauge), therefore it is unlikely to be representative of the situation and catchment response at the study site, which is much further upstream in the upper catchment.	AM	n/a	17.52	29.42	0.575

3.3 Overview of estimation of QMED at each subject site

Site code	QMED from CDs (m^3/s) RURAL	Final method	Data transfer						Final estimate of QMED (m^3/s) URBAN*
			NRFA numbers for donor sites used (see 3.2)	Distance between centroids d_{ij} (km)	Power term, a	Moderated QMED adjustment factor, (A/B)[a]	If more than one donor		
							Weight	Weighted ave. adjustment	
RB_01	9.02	CD	n/a	n/a	n/a	n/a	n/a		10.46
FB_01	1.21	CD		n/a	n/a				1.27
RB_02	10.59	CD		n/a	n/a				12.02
Are the values of QMED spatially consistent?						Yes, they increase downstream and match the relative catchment areas.			

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment).

When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added below.

The QMED adjustment factor A/B for each donor site is given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

If more than one donor has been used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the penultimate column.

Important note on urban adjustment

The method used to adjust QMED for urbanisation, for both subject sites and donor sites, is that published in Kjeldsen (2010)[3] in which PRUAF is calculated from BFIHOST. The result will differ from that of WINFAP-FEH v3.0.003 which does not correctly implement the urban adjustment of Kjeldsen (2010). Significant differences will occur only on urban catchments that are highly permeable.

* Final QMED value adjusted for urbanisation using Kjeldsen (2010)

[3] Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. **41**. 391-405.

3.4 Derivation of pooling groups

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (enhanced single site analysis)	Changes made to default pooling group, with reasons .	Weighted average L-moments, L-CV and L-skew, (before urban adjustment)
RB_PG	RB_02	No	Pooling group is heterogeneous and was reviewed. No stations were removed or added. 531 years' data.	L-CV: 0.247 L-SKEW: 0.167
Notes Pooling groups were derived using the procedures from Science Report SC050050 (2008).				

3.5 Derivation of flood growth curves at subject sites

Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period
RB_01	P	RB_PG	Generalised Logistic (GL): this is the distribution recommended for UK catchments. The GL distribution provides the best fit to the data.	Growth curve adjusted using v3 urban adjustment. No permeable adjustment. required	Location: 0.870 Scale: 0.352 Shape: -0.022	2.58
FB_01	P				Location: 0.861 Scale: 0.379 Shape: 0.001	2.60
RB_02	P				Location: 0.867 Scale: 0.361 Shape: -0.015	2.58
Notes Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters. Urban adjustments are all carried out using the v3 method: Kjeldsen (2010). Growth curves were derived using the procedures from Science Report SC050050 (2008).						

3.6 Flood estimates from the Statistical method

Site code	Flood peak (m^3/s) for the following return periods		
	1 in 20-year (5% AEP)	1 in 100-year (1% AEP)	1 in 1,000-year (0.1% AEP)
RB_01	17.6	27.0	36.6
FB_01	2.2	3.3	4.4
RB_02	20.4	31.1	42.0

4 Revitalised Flood Hydrograph (ReFH) Method

4.1 Parameters for ReFH model (rural catchments)

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
RB_01	CD	3.2	362	33	1.26
FB_01	CD	2.0	430	34.8	1.54
RB_02	CD	3.82	391	37.8	1.38
Brief description of any flood event analysis carried out (further details should be given in the annex)		n/a			

4.2 Design events for ReFH method

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)	Storm area for ARF (if not catchment area)
RB_01	Rural	Winter	6.25	-
FB_01	Rural	Winter	3.75	-
RB_02	Rural	Winter	7.25	-
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?			The different storm durations above were used to derive the lumped flood estimates below but the same storm duration will be used for all inflows in the model. As the site is located just upstream of the confluence with the Fulford Brook and upstream of another incoming drainage catchment, a storm duration of 6.75 hours will be used and a timestep of 0.25, representative of the response at the site, between the upstream and downstream ends of the model.	

4.3 Flood estimates from the ReFH method

Site code	Flood peak (m^3/s) for the following return periods (in years)		
	1 in 20-year (5% AEP)	1 in 100-year (1% AEP)	1 in 1,000-year (0.1% AEP)
RB_01	20.3	28.6	50.4
FB_01	3.0	4.3	7.9
RB_02	23.7	33.2	58.2

5 Discussion and summary of results

4.4 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	The ReFH method yielded more conservative results than the FEH Statistical method; however, the FEH Statistical method is the preferred method as a larger dataset of gauged data was used in the calibration of the method and it has been more directly calibrated to reproduce flood frequency on UK catchments. Following investigation of three potential donors to improve Qmed estimates, including one donor which was located within the study catchment, the estimation of QMED was based on catchment descriptors due to the potential donor gauges' being urbanised or affected by reservoir influence. No observed data is available to derive a hydrograph shape for input into the model. In the absence of this data, a hybrid approach has been taken with ReFH used to generate an inflow hydrograph which was then scaled to the Statistical peak. An intervening catchment will be used in the model to represent the contribution of the catchment between the upstream inflows points and the downstream extent.

4.5 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	It is assumed that: • QMED estimated from catchment descriptors is representative • The pooling group is representative of the study catchment • ReFH hydrograph shape is representative of the catchment response.
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	• The FEH Statistical method is generally believed to only be suitable for return periods up to 200 years (0.5% AEP event). ReFH is calibrated for return periods up to 150 years (0.67% AEP event). Estimates of flows beyond these return periods are extrapolations and have a higher degree of uncertainty.
Give what information you can on uncertainty in the results, e.g. confidence limits from Kjeldsen (2014).	For the FEH Statistical method, the uncertainty will depend on a variety of factors, for example, how unusual the catchment is relative to the pooling group and donor catchment, and the uncertainty in flow measurement at other gauges. Recent guidance on the reliability of design flood estimates in the UK (Kjeldsen, 2014) quotes average UK measures of uncertainty. The 95% confidence limits for a 1% AEP event flood estimate are: • Without donor adjustment of QMED (CDs): 0.42 - 2.37 times the best estimate • With donor adjustment of QMED (DT): 0.45 - 2.25 times the best estimate
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	It is emphasised that the results of the analysis should be considered in the context of the needs of this study. The results of this assessment should be revisited for use on future studies.
Give any other comments on the study, e.g. suggestions for additional work.	The un-gauged catchment would benefit from local data to refine flow estimates, perhaps a temporary flow logger to be installed on the River Blithe in the upper catchment (as Hamstall Ridware gauge is located downstream of the reservoir in the lower catchment).

4.6 Checks

Are the results consistent, for example at confluences?	Yes, flows are consistent along the modelled reach.
What do the results imply regarding the return periods of floods during the period of record?	N/A – The catchment is not gauged at this point.
What is the range of 100-year growth factors? Is this realistic?	The 100-year growth factor for the flow estimation points is 2.58-2.60. This falls within the typical range stated in the guidance (2.1 – 4.0)
If 1,000-year flows have been derived, what is the range of ratios for 1,000-year flow over 100-year flow?	1,000-year flows have been derived using the Statistical method. The range of ratios for 1,000-year flow over 100-year flow for the flow estimation points is 1.33-1.36
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	Previous Flood Risk Assessments and modelling work has been undertaken along this watercourse for this site: • Blythe Business Park Development FRA (Jacobs, 2014) • Technical review of the River Blithe Flood Model – Addendum Flood Map Challenge (RPS, 2012). Any comparable results will be reviewed for sensibility checking purposes.
Are the results compatible with the longer-term flood history?	n/a
Describe any other checks on the results	Sensibility checks will be applied to the flood outlines once the flows have been routed through the model, to ensure that flow inputs result in realistic outputs.

4.7 Final results

Site code	Flood peak (m^3/s) for the following return periods		
	1 in 20-year (5% AEP)	**1 in 100-year (1% AEP)**	**1 in 1,000-year (0.1% AEP)**
RB_01	17.6	27.0	36.6
FB_01	2.2	3.3	4.4
RB_02	20.4	31.1	42.0

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below)	In the absence of any observed data for the watercourses, ReFH boundary units will be used in the model to obtain hydrograph shapes, scaled to the FEH Statistical peak flows. Intervening catchments will be represented using ReFH boundary units.

5 Annex

A.1 Pooling Group composition

Station ref.	SDM Distance	Years of Data	QMED AM	L-CV	L-Skewness	Discordancy
53017 (Boyd @ Bitton)	0.255	39	13.073	0.243	0.112	0.079
41020 (Bevern Stream @ Clappers Bridge)	0.365	43	13.490	0.214	0.208	0.642
41022 (Lod @ Halfway Bridge)	0.379	39	16.044	0.287	0.214	0.631
42011 (Hamble @ Frogmill)	0.397	40	8.028	0.159	0.013	1.135
43806 (Wylye @ Brixton Deverill)	0.445	21	1.914	0.383	0.222	2.401
28058 (Henmore Brook @ Ashbourne)	0.520	14	9.006	0.168	-0.102	1.495
44003 (Asker @ Bridport)	0.521	30	14.636	0.253	0.221	0.094
76019 (Roe Beck @ Stockdalewath)	0.533	13	43.521	0.213	0.365	1.858
39033 (Winterbourne Stream @ Bagnor)	0.539	50	0.393	0.336	0.369	1.889
30004 (Lymn @ Partney Mill)	0.609	50	6.778	0.236	0.059	0.262
24007 (Browney @ Lanchester)	0.627	15	10.981	0.222	0.212	1.284
49004 (Gannel @ Gwills)	0.631	43	14.046	0.252	0.116	0.463
49002 (Hayle @ st Erth)	0.661	55	4.386	0.245	0.243	0.146
28041 (Hamps @ Waterhouses)	0.667	27	26.664	0.230	0.309	1.573
26003 (Foston Beck @ Foston Mill)	0.689	52	1.739	0.243	-0.015	1.049
Total		531				
Weighted means				0.247	0.167	

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F Peak flow and water level

Table 4-1 shows the peak water level and flow during the 100-year plus climate change (50%) baseline scenario.

Table 4-1: Peak flow and water level for the 100-year plus climate change (50%) baseline scenario

Cross section node	Max Flow (m^3/s)	Max Stage (m AOD)
BLI_1663	19.7	157.60
BLI_1594	12.9	157.58
BLI_1594D	12.9	157.58
BLI_1594SU	0.0	157.58
BLI_1594B	12.9	157.58
BLI_1594BD	12.9	157.58
BLI_1594SD	0.0	157.58
BLI_1489	9.2	157.48
BLI_1374	39.7	157.51
BLI_1374D	39.7	157.24
BLI_1364	39.8	157.18
BLI_1278	44.3	156.85
BLI_1188	39.1	156.41
BLI_1145	35.2	156.37
BLI_1145B	35.2	156.37
BLI_1145BD	35.2	156.27
BLI_1145D	35.2	156.27
BLI_1145SU	0.0	156.37
BLI_1145SD	0.0	156.27
BLI_1032	38.4	155.43
BLI_862	21.8	155.07
BLI_862B	21.7	155.07
BLI_862BD	21.7	154.93
BLI_862D	21.8	154.93
BLI_862SU	1.6	155.07
BLI_862SD	1.6	154.93
BLI_773	31.7	154.61
BLI_673	37.3	154.12
BLI_648	21.1	154.12
BLI_530	37.0	153.52
BLI_420	35.9	153.09
BLI_391	30.2	152.97
BLI_391B	30.2	152.97
BLI_391BD	30.2	152.74
BLI_391D	30.2	152.74
BLI_391SU	0.0	152.97
BLI_391SD	0.0	152.74
BLI_181	20.1	151.74
BLI_0	19.0	151.11
BLI_0D	19.0	150.99
BLI_dsbdy	18.3	150.30

BLI_1813	40.5	157.85
FUL_794	5.0	160.40
FUL_680	5.0	158.84
FUL_560	5.0	157.84
FUL_12	2.5	154.12
RB_01	40.5	157.85
FB_01	5.0	160.40
RB_LAT	9.4	-9999.97
BLI_181L	4.7	151.74
FUL_499	3.8	157.81
FUL_499CU	3.8	157.64
FUL_499CD	3.8	157.40
FUL_492	3.8	156.88
FUL_425	4.7	156.67
FUL_345	4.7	156.20
FUL_273	4.8	155.65
FUL_193	4.8	155.02
FUL_115	5.0	154.41
FUL_37	2.8	154.19
FUL_25	2.6	153.94
FUL_19	2.5	154.16
BLI_1364L	4.7	157.18

G Flood Alleviation Options

TECHNICAL NOTE

JBA Project Code	2017s5747
Contract	Blythe Park hydraulic modelling
Client	Wardell Armstrong
Day, Date and Time	13/07/2017
Author	Alice Blanchard
Reviewer / Sign-off	Sophie Dusting
Subject	Additional modelling

1 INTRODUCTION

1.1 Study context

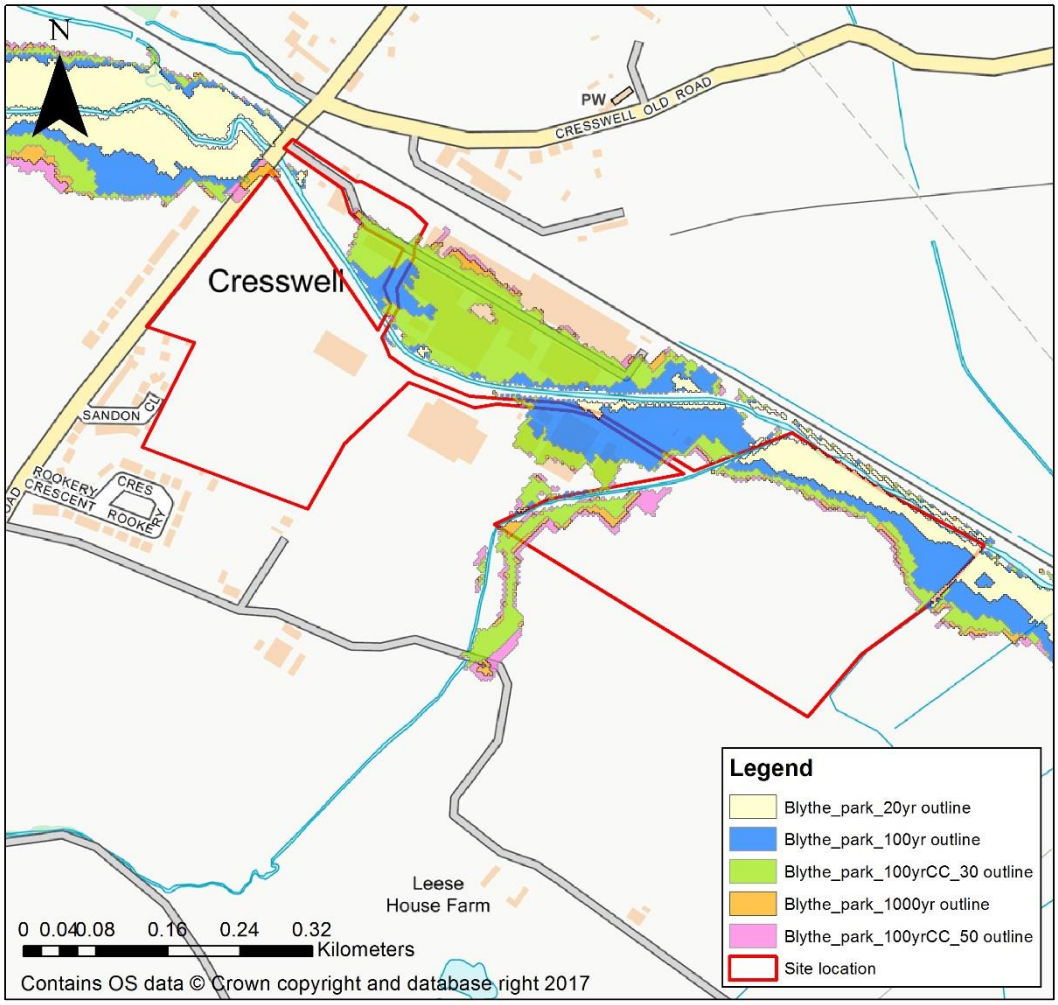
JBA Consulting was commissioned by Wardell Armstrong LLP to investigate flood alleviation options for a site in Blythe Park, Cresswell. Two proposed flood alleviation options were proposed; upsizing of a culvert along the Fulford tributary and the addition of a flood bund on site.

To support this analysis, the 1D-2D River Blithe model representing the River Blithe and the Fulford tributary (produced by JBA Consulting) was used to simulate the 100-year plus climate change (50%) event with the two proposed flood alleviation options and quantify its impact on flood depths.

2 HYDRAULIC MODELLING

The baseline flood extent associated with the 20-year, 100-year, 100-year plus climate change (30%), 100-year plus climate change (50%) and 1,000-year event are shown in Figure 2-1.

Figure 2-1: Baseline flood extents for the 20-year, 100-year, 100-year plus climate change (30% and 50%) and 1,000-year events



The baseline model results show that in the 100-year plus climate change (30%), 100-year plus climate change (50%) and 1,000-year flood events, the culvert along the Fulford tributary surcharges and pushes water over the right bank of the watercourse, and flows towards the development site.

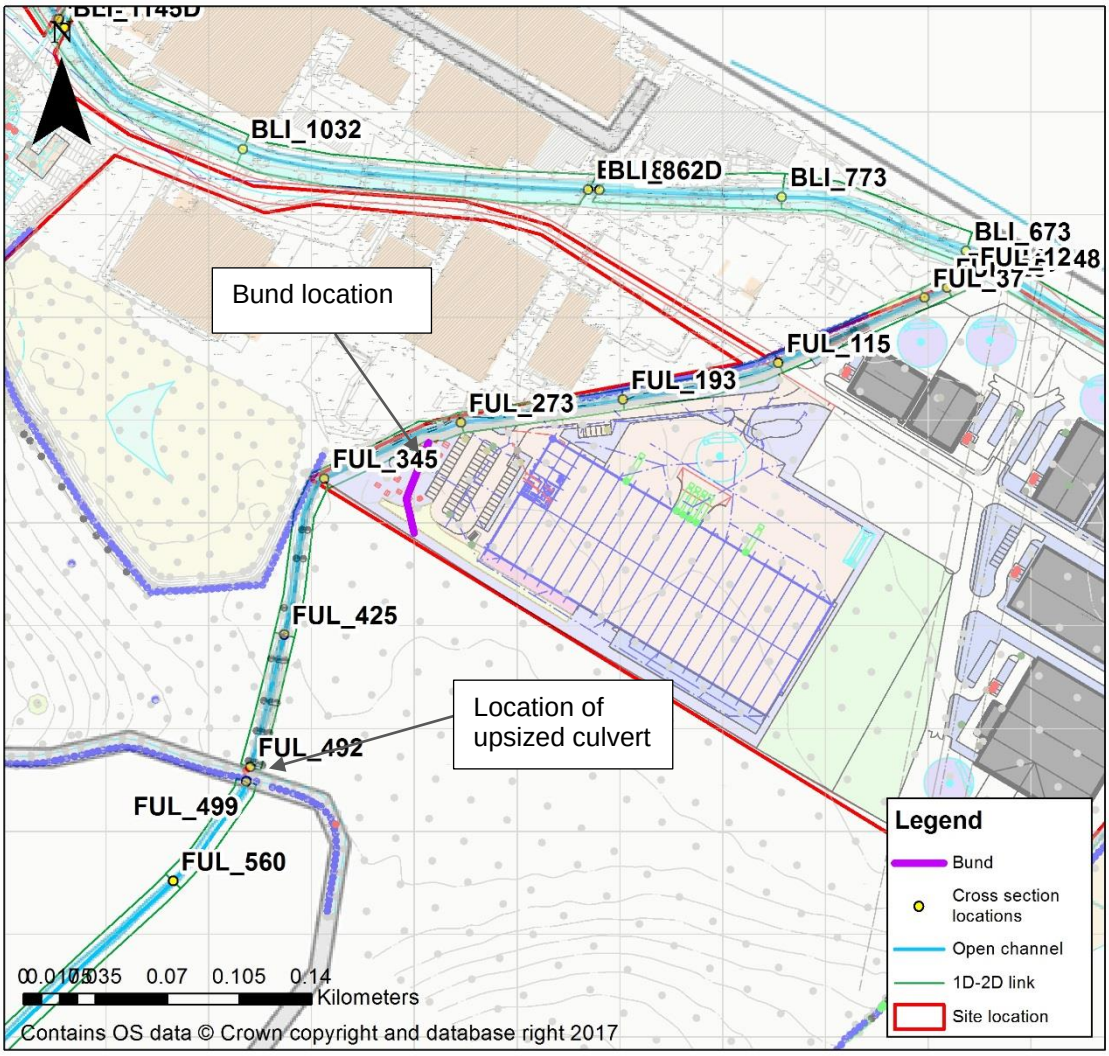
2.1 Flood alleviation options

Two flood alleviation options were modelled in order to reduce flooding to the south-western part of the site:

- Option 1: Upsizing of the culvert along Fulford tributary (at FUL_499) from a 1.2m circular pipe to a 1.75m x 1m rectangular culvert. The length and invert level of the culvert remains unchanged from the original culvert i.e. a length of 7.2m and an invert level of 155.770m AOD).
- Option 2: Addition of a flood bund, 46m in length, with a glasswalled crest level.

The location of the upsized culvert and the bund are shown in Figure 2-2.

Figure 2-2: Location of proposed flood alleviation options



2.2 Model runs

The model was run for the 100-year plus climate change (50%) flood event for each option during the post-development scenario (which includes glasswalled buildings). The impact of the proposed-scheme was assessed against the 100-year plus climate change (50%) baseline scenario.

3 RESULTS

3.1 Peak flood depths and flood extent

Figure 3-1 and Figure 3-2 shows the flood extent and peak flood depths during the 100-year plus climate change (50%) scenario for option 1 and option 2 respectively.

Figure 3-1: Peak flood depths during the 100-year plus climate change (50%) post-development option 1 scenario

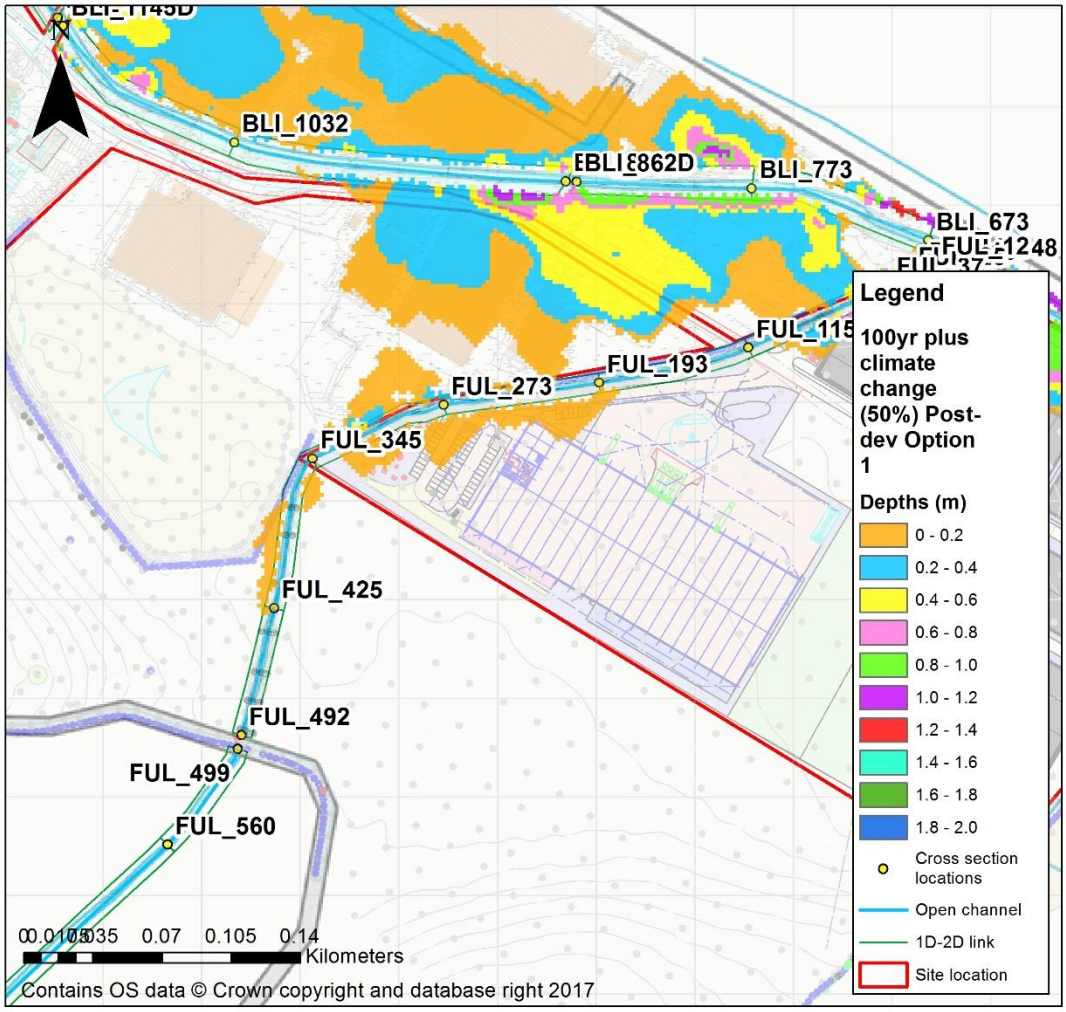


Figure 3-1 shows that in option 1, the upsized culvert removes the flow path towards the development site along the right bank of the Fulford tributary. However, water still overtops the right and left banks of the Fulford tributary further downstream.

Figure 3-2: Peak flood depths during the 100-year plus climate change (50%) post-development option 2 scenario

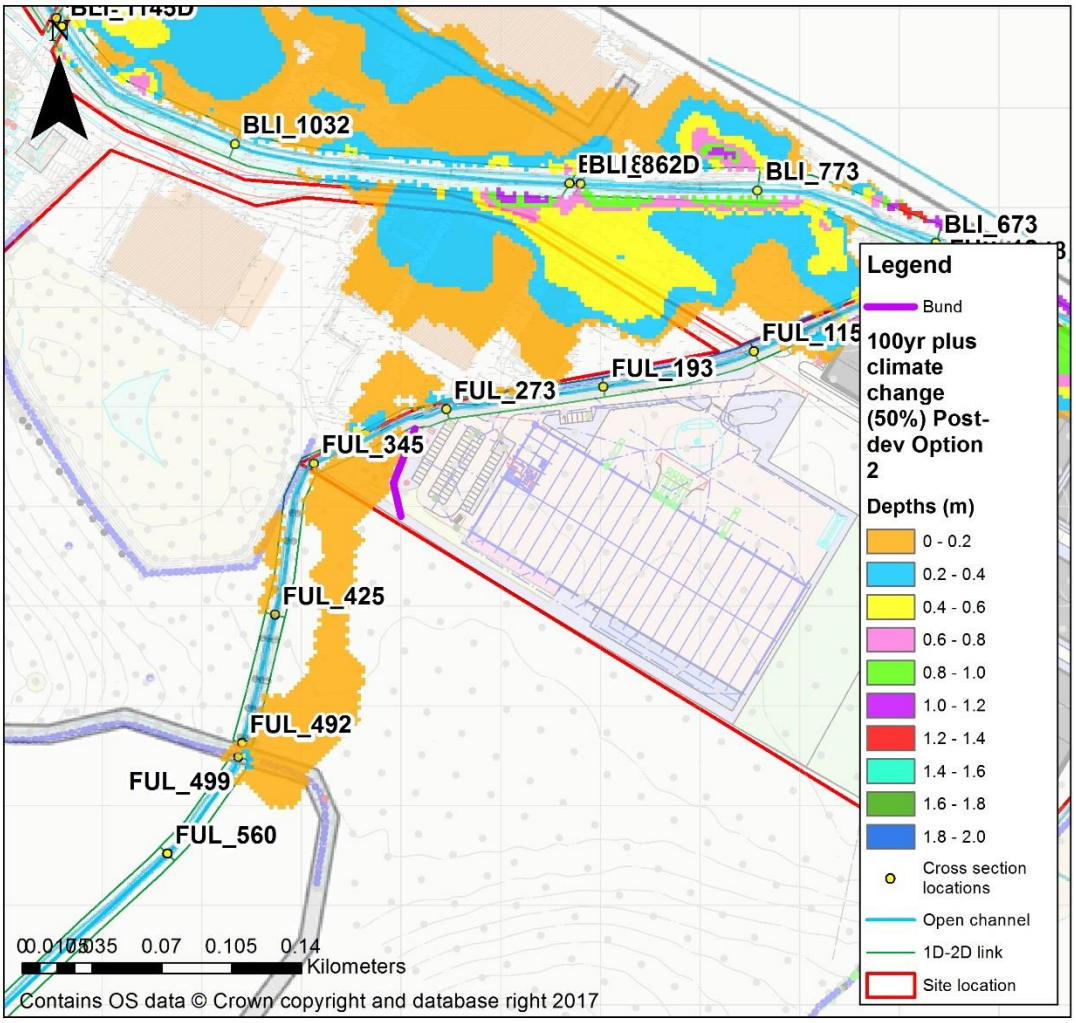
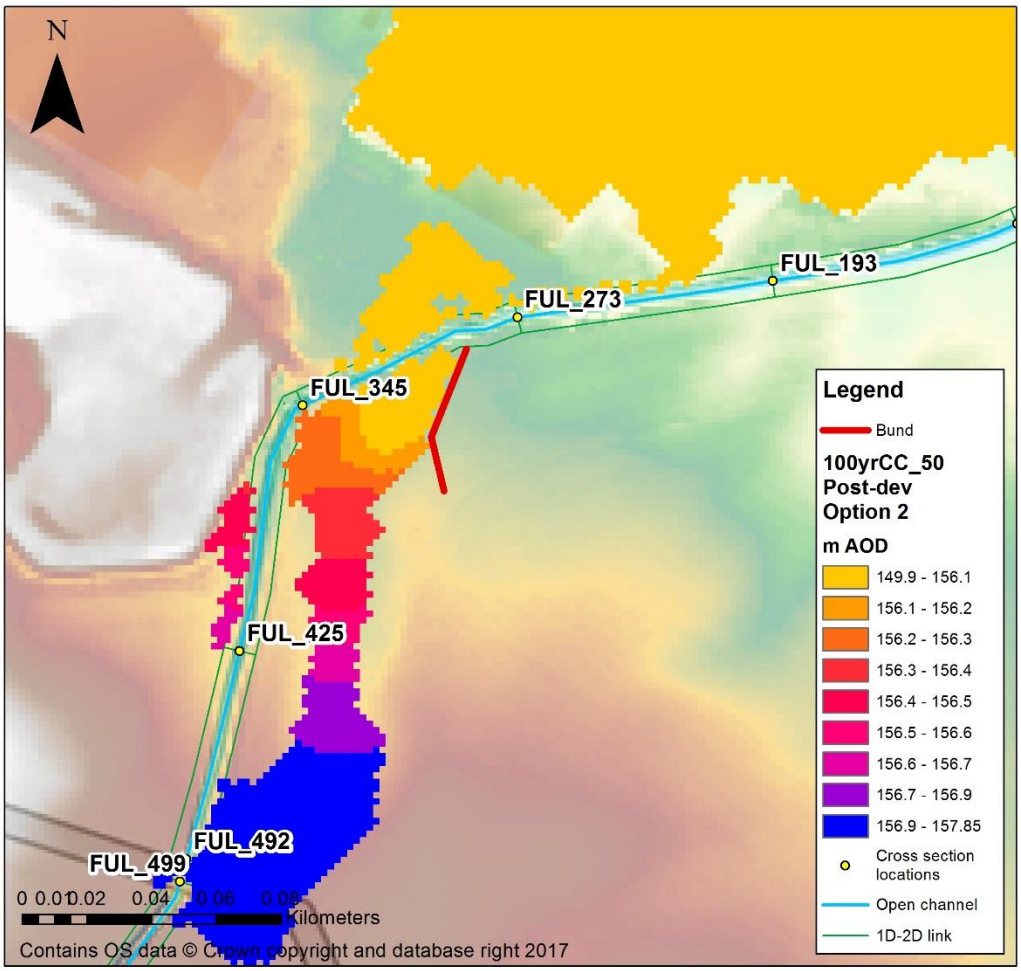


Figure 3-2 shows that in option 2, the bund prevents water propagating further into the site. Flood depths behind the bund are still relatively shallow (maximum 0.2m depths). Figure 3-3 shows the maximum elevation of water behind the bund during the 100-year plus climate change (50%) post-development option 2 scenario.

Figure 3-3: Peak elevation of water behind the bund during the 100-year plus climate change (50%) post-development option 2 scenario



3.3 Impact of proposed flood alleviation options

The impact of each proposed flood alleviation option on flood depths during the post-development 100-year plus climate change (50%) event is shown in Figure 3-4 and Figure 3-5.

Figure 3-4: Impact on flood depths during the 100-year plus climate change (50%) post-development option 1 scenario

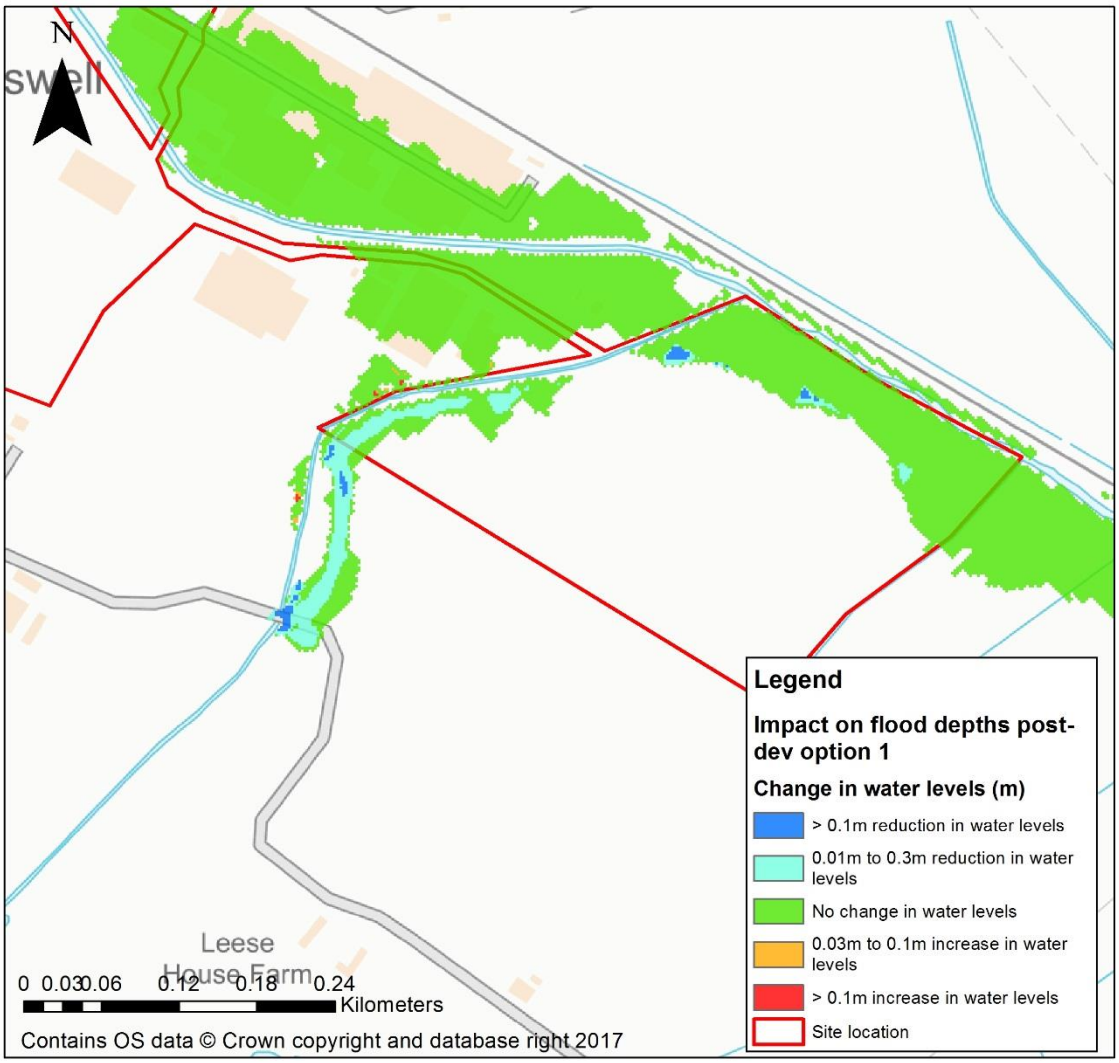


Figure 3-5: Impact on flood depths during the 100-year plus climate change (50%) post-development option 2 scenario

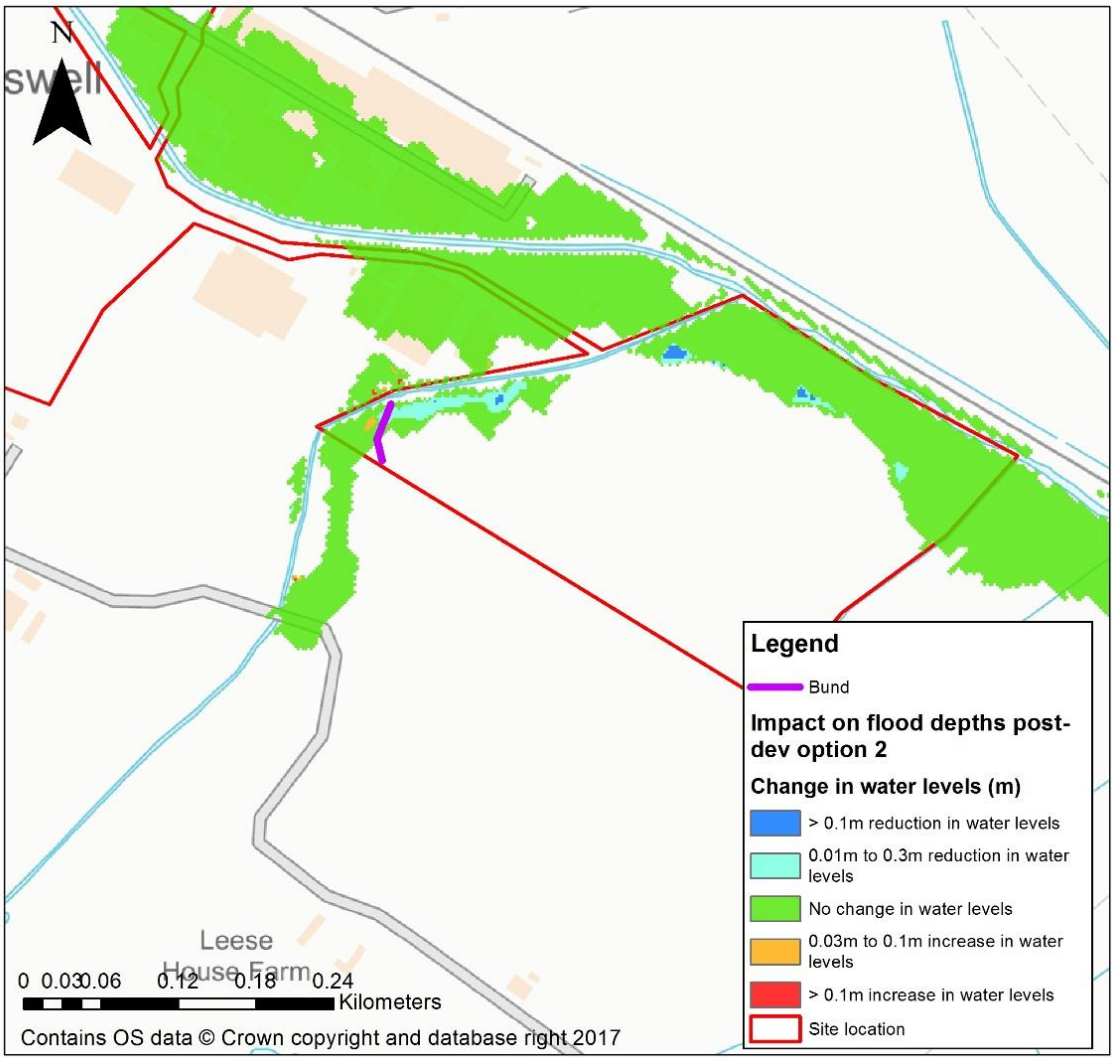


Figure 3-4 and Figure 3-5 show that largely, the post-development option 1 and option 2 scenarios do not impact flood depths. There are small areas where increases in flood depths are shown, though this is not within areas of existing buildings. The total area of land where an increase in flood depth occurs outside of the site boundary is 108m^2 and 84m^2 for options 1 and 2 respectively. Although the increases in flood depth are shown to be outside of the site boundary, they are understood to still be within the site ownership boundary.

4 CONCLUSIONS

- JBA Consulting was commissioned by Wardell Armstrong to investigate flood alleviation options for a site in Blythe Park, Cresswell.
- Two proposed flood alleviation options were proposed; upsizing of a culvert along the Fulford tributary and the addition of a flood bund on site.

- Each option was run for the 100-year plus climate change (50%) post-development scenario.
- Model results show that largely, both options do not impact flood depths. Small areas of increase in flood depths are shown, but not within areas of existing buildings. The increases in depths are understood to be within the site ownership boundary.

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